Project Overview

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U.S. ATLAS HL-LHC Upgrade Project Manager (A)

January 20, 2016

Outline

- The CERN HL-LHC Process
- The International ATLAS Collaboration HL-LHC Activities
- U.S. ATLAS HL-LHC Project
  - Organization
  - DOE/NSF Guidance
  - DOE/NSF Scope
  - Basis of Estimates
  - Risk
  - Contingency
  - Budgets

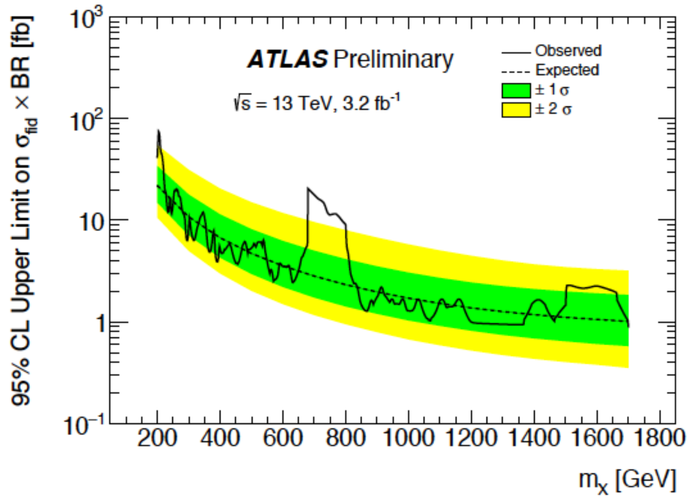
Motivation

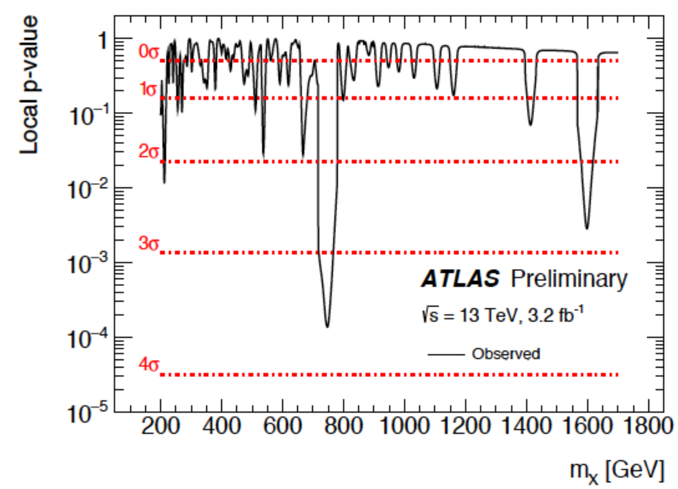
❖ From the P5 report:

- "The Phase-2 luminosity upgrade (HL-LHC) is required to fully exploit the physics opportunities offered by the ultimate energy and luminosity performance of the LHC."

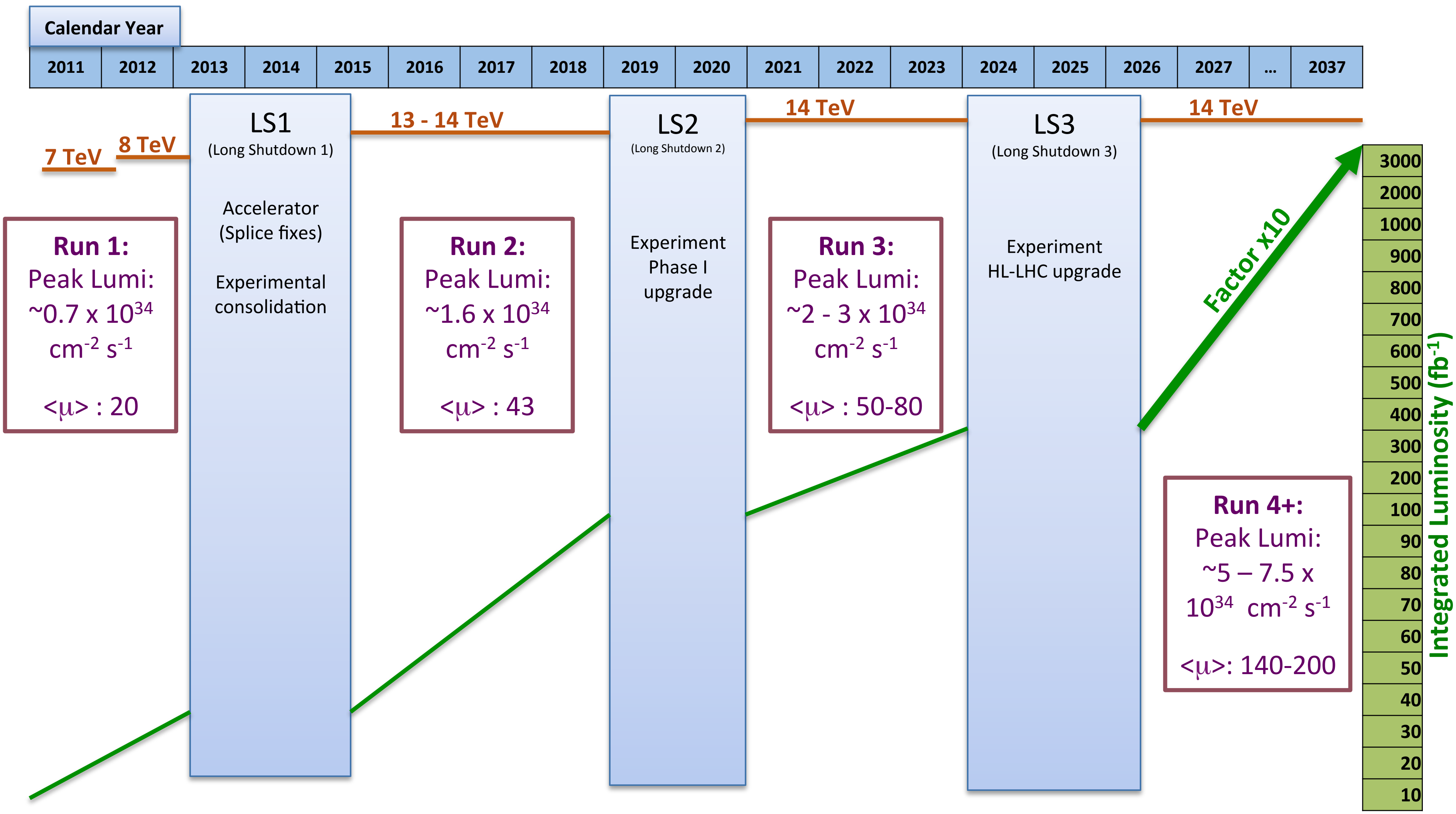
❖ Addresses three of the five science drivers identified by P5:

- Use the Higgs boson as a new tool for discovery
- Identify the new physics of dark matter
- Explore the unknown: new particles, interactions, and physical principles





The HL-LHC Plan



CERN Experiment Upgrade Approval Process

❖ CERN management, in coordination with the Resource Review Board (RRB), has identified a four-step HL-LHC approval and verification process:

1) **The overall scope and cost for the entire upgrade program for each experiment will be defined**, with the possibility to maintain different options which may depend on technical issues and/or on funding availability.
2) **The detailed technical design reports for the various subsystems will be reviewed.** These TDRs will naturally come at different times depending on the maturity of the projects, and will be reviewed individually, with the requirement that each fits in the overall approved plan for scope and cost (Project Baseline)
3) **The final design and construction readiness of the major detector components will be reviewed**. As in the second step, different sub-systems, and in some cases also different elements of the subsystems, will be ready at different times, and will be reviewed accordingly, with the requirement that they are compatible with the overall construction and installation plan (Start of Construction).
4) As sub-systems are coming together in the experiment, **an operation readiness review should be held** to evaluate the capability of the completed detectors to provide the expected performance and mark the end of the Phase II upgrade construction project. (Project Completion).

Upgrade Approval Process

- In preparation for Step 1, the experiments were asked to present their plans, including the impact on physics for three possible funding scenarios:
  - 200, 235 and 275 MCHF in units of "CORE COST".
  - The experiments were also asked to submit a preliminary money matrix specifying the potential available funding from various FAs.
- In response to this request, ATLAS has put together a "scoping document" detailing the upgrade option for each scenario, the physics impact and the preliminary "money matrix".
  - ATLAS Scoping Document: https://cds.cern.ch/record/2055248 (DocDb # 45)
- This was reviewed by the LHC Experiments Committee (LHCC, chaired by F. Forti) and by the Upgrade Cost Group (UCG, chaired by S. Smith), and their conclusions reported to Resource Review Board (RRB) (10/15)
  - "Both experiments have attained a level of preparation and understanding that meet, and in some areas exceed, requirements for Step 1 approval."
  - **"The ATLAS and CMS Phase II upgrade projects are ready to proceed to Step 2 [TDR] that will establish a baseline cost and schedule for construction."**

Summary of LHCC/UCG/RRB:

(https://indico.cern.ch/event/407749/)

Based on the LHCC/UCG findings and the subsequent endorsement by the CERN Management, the following statement was endorsed by the RRB :

"The RRB considers the Step 1 of the approval process for the Phase II Upgrades for the ATLAS and CMS experiments ***successfully completed****.*

A ***scale of funding*** *between the full funding and the intermediate scenario seems to meet the performance requirements.*

The CERN Management, supported by the recommendations of the LHCC and the UCG, deems as realistic the availability of prospective funds contained in the preliminary "Money Matrices" submitted by the experiments.

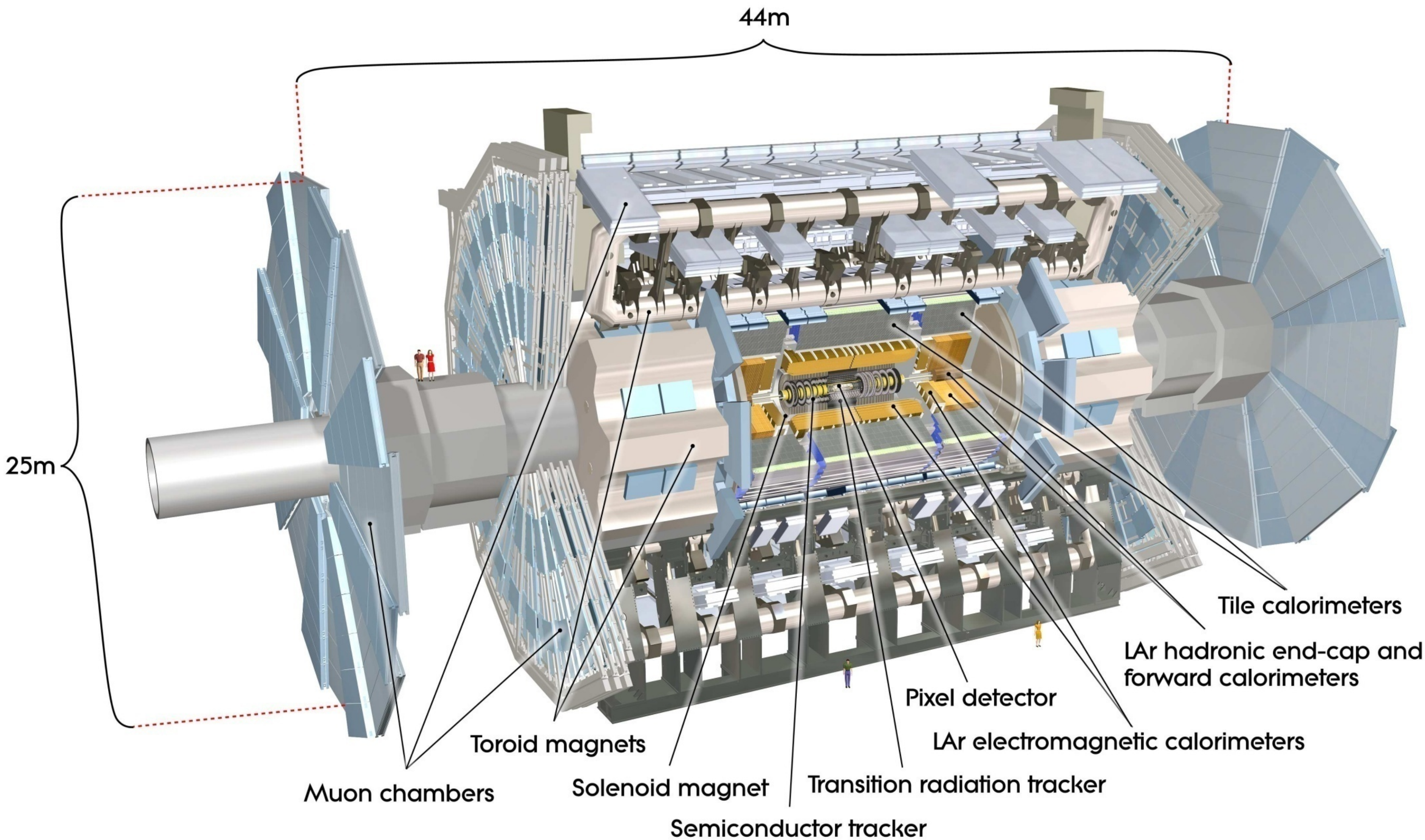
The experiments are therefore encouraged to proceed to the next step of the Phase II upgrades, as described in the document CERN-LHCC-2015-007. The LHCC and the UCG as well as the Management will regularly update the RRB on progress of the process."

International ATLAS Planning for HL-LHC

HL-LHC Upgrades

- The current ATLAS detector was designed to operate at a luminosity of 10^{34} cm^{-2} s^{-1}, ~25 interactions/p-bunch-crossing and a 100 kHz Level-1 trigger rate for an integrated luminosity ~ 300 fb^{-1}.
  - The ongoing construction for Phase I upgrades is focused on providing additional triggering capabilities to allow operation at ~2 x 10^{34} cm^{-2} s^{-1}.
- The HL-LHC upgrades for the ATLAS detector are driven by:
  - The aging of the Inner Tracker, mostly due to radiation.
  - Increased occupancy and data volumes saturating readout links of the existing readout electronics.
  - The need to maintain low triggering thresholds with increasing trigger rates, to maintain physics acceptance.
  - Preparation for running over a decade at very high luminosity
    - > 5 x 10^{34} cm^{-1} s^{-1} with 140-200 interactions/crossing
    - Particle fluxes and energy deposition ~5 times higher than original design

The ATLAS Detector



The Upgrades

- Consequently, the primary elements of the detector upgrades in the reference scenario include:
  - Full Replacement of the Inner Tracker with an all-Si technology
    - Driven by the need to maintain tracking performance in a high radiation, high occupancy environment and to provide additional acceptance in the very forward region.
  - New Trigger/DAQ architecture
    - Driven by the need to retain low p_T thresholds at high luminosity to maintain physics acceptance and to handle increased DAQ rates.
  - New readout electronics for all systems
    - Driven by the need to handle increased readout data rates and providing additional handles for the trigger stage.
  - Other Options under consideration include:
    - Replacement of the Forward calorimeter and the innermost Muon chambers, installation of a forward timing detector & forward muon tagger.

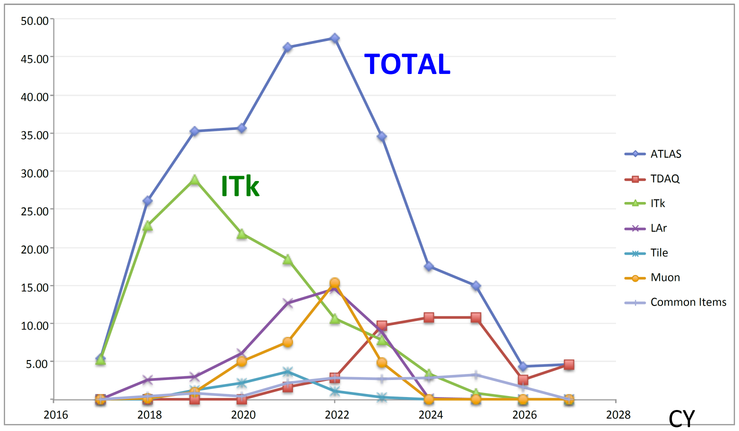
ATLAS HL-LHC Documents

- ATLAS HL-LHC Letter of Intent (LoI) completed and endorsed by collaboration at end of 2012
  - https://cds.cern.ch/record/1502664 (DoCDb# 69)
  - Provides a description of the Phase II upgrades with physics justification and an initial cost estimate.
- The "scoping document" was released on 9/2015:
  - https://cds.cern.ch/record/2055248 (DoCDb# 45)
  - The document described the proposed "Reference Detector" for the HL-LHC (corresponding to Core cost of 271 MCHF) with possible reductions corresponding to the Middle Scenario (228 MCHF) and Low Scenario (200 MCHF) and the corresponding physics impact:
    - Performance and physics reach is significantly enhanced with the Reference Scenario. In some physics searches, x2 (x4) integrated luminosity is required in the Middle (Low) Scenario to achieve the same significance as the Reference Scenario.

The Reference Detector

- **The Silicon Tracker (ITk):** 4 layers of pixel detector and 5 layers of Strip Detector and an extension of tracking to $|\eta| = 4.0$.
  - A task force is in place to further optimize this layout by mid-2016 (cost-neutral wrt reference scenario).
- **LAr Calorimeter:** Full readout electronics upgrade to allow 40 MHz streamed off detector for trigger consideration.
  - A forward Calorimeter and a timing detector has also been included.
- **Tile Calorimeter:** Full readout electronics upgrade to allow 40 MHz streamed off detector for finer trigger consideration.
- **Muon System:** Replacement of all on-chamber electronics, and replacement of MDTs with sMDT+RPC in the inner-barrel region.
- **Trigger/DAQ:** Two level hardware trigger (L0/L1) with a max rate of 1 MHz/400 kHz with 6 μs/30 μs latency and 10 kHz to disk.

ATLAS Core Cost Summary



Estimated spending profile for the reference scenario for each sub-system shown above.

Sub System (Core Cost in MCHF)	Reference Detector	Middle Scenario	Low Scenario
Silicon Tracker (ITk)	120.4	-7.2	-23.6
LAr Calorimeter	46.0	-13.6	-13.6
Tile Calorimeter	8.6	-	-
Muon System	34.1	-8.8	-12.8
Trigger/DAQ	43.3	-11.4	-18.2
Forward Detector	1.3	-	-
Integration & Installation	17.4	-1.6	-3.0
TOTAL	**271.1**	**-42.6**	**-71.2**

Estimate for Ref. scenario & reductions for Mid/Low

- The costing for each sub-system, incl. profile, has been worked out in detail. Major input from US experts and managers and experience from Phase-I in this process.
  - The ITk has the longest construction time and requires funding early on. Production phase for ITk is expected to begin in FY19.
- ATLAS management has gathered input from all countries on their potential contributions to the HL-LHC upgrades, which has been discussed with LHCC/UCG.
  - Initial consultation suggests a realistic possibility for securing the needed funds.
  - U.S. contribution is planned to be ~20% of the “core cost”, comparable to its “fair-share”.

U.S. ATLAS Planning for HL-LHC

U.S. ATLAS

- The process of finalizing US contributions to ATLAS HL-LHC upgrades is complex : involving coordination between US groups, international ATLAS, and US funding agencies.
- Key Steps that have been completed include:
  - Phase-II organization in place with acting project managers.
  - Aspirations based on experience and expertise of US groups collected.
  - Top-Down prioritization based on uniqueness of US contributions, budget profiles and baseline to meet funding guidance
  - Identify scope for DOE and NSF deliverables that meet their budget guidance.
  - Bottom-Up cost estimate of US proposed deliverables, incl. Labor.
    - WBS, Scope, Cost Books, BoE, Risks, and Contingency, available for review

Details will be presented in the breakout sessions

U.S. ATLAS HL-LHC Organization

Management Advisory Committee (MAC)
Chair M. Shochet (Chicago)

Project Manager (DOE), S. Rajagopalan (BNL) (A)
Deputy Project Manager (NSF), M. Tuts (Columbia) (A)

Joint Integration Group (JIG) Chair, J. Kotcher

<u>Education & Outreach</u>
E&O Coordinator, TBD

<u>Management Team</u>
Technical Coordinator, H. Evans (Indiana)
R&D Liaison, A. Seiden (UCSC)
OP Liaison, J. Cochran (Iowa State)
Phase I Liaison, C. Bee (Stony Brook)
Project Engineer, TBD
System Integration Engineer, TBD

<u>Technical Team</u>
ITK Electronics System Integrator, TBD
ITK Mechanics System Integrator, TBD
LAr System Integrator, TBD
TileCal System Integrator, TBD
Muon System Integrator, TBD
Trigger System Integrator, TBD
Cybersecurity Liason, TBD
ES&H Liaison, R. Gill (BNL)
QA/QC Liaison, J. Eng (BNL)

<u>Project Controls/Administration Team</u>
Financial Analyst DOE, C. Butehorn (BNL)
Financial Analyst NSF, TBD (Columbia)
P6 Consultant, TBD
P6 Scheduler DOE, TBD
P6 Scheduler NSF, TBD
Administrator DOE PO, W. Yu (BNL)
Administrator NSF PO, A. Garwood (Columbia)

<u>U.S. ATLAS Detector Subsystems</u>
Level 2 Managers for ITK Pixels, ITK Strips, ITK Common, LAr, TileCal, Muons, Trigger, DAQ

DOE: Guidance & Process

- Current R&D will be supported by the U.S. ATLAS Operations Program until HL-LHC project funds (OPC) materialize.
  - OPC funds are planned to support prototyping effort prior to start of production.

(M$)	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	*Total*
OPC	1.25	14.0							*15.25*
TEC			31.5	42.3	26.1	20.1	10.0	4.75	*134.75*
TPC	1.25	14.0	31.5	42.3	26.1	20.1	10.0	4.75	*150.00*

- CD-0 for HL-LHC is expected early 2016. This will allow OPC funds to begin flowing in FY17.
- Given our experience with Phase I, we expect CD-1 will take place 1 – 1.5 years after CD-0, followed by a CD-2/3 (by ~ end of 2018).

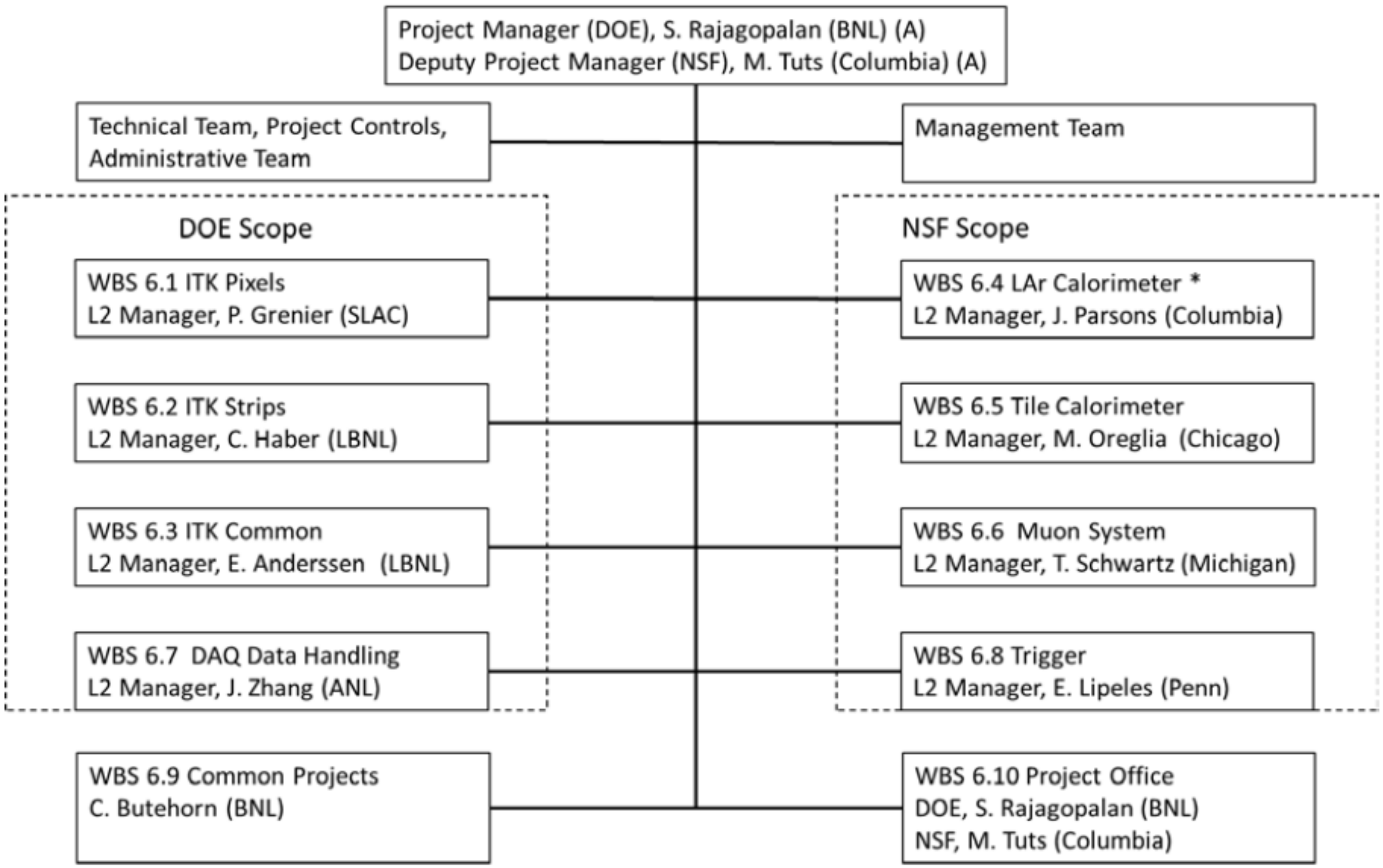
NSF: Guidance & Process

- U.S. ATLAS and U.S. CMS will submit a joint MREFC proposal, with an expected funding of up to $75M per experiment.
  - In practice, two proposals under a unified MREFC umbrella.
  - Science Case document completed in May 2015 and NSF Director has given permission to move forward to a Conceptual Design Review (CDR).
  - We are currently preparing for the CDR, including putting together a Project Execution Plan (PEP). We are targeting the CDR for March 2016.
    - This will be followed with a Preliminary Design Review (PDR). Following a successful PDR, NSF will submit a single MREFC appropriation request for construction as part of FY20 budget request to Congress. Two separate awards will be made to fund US ATLAS and US CMS proposals.
    - A Final Design Review will occur early FY20 prior to the release of MREFC funds.
- Two sources of funds to support R&D and prototyping through FY20:
  - U.S. ATLAS Operations Program, that will contribute ~$1M per year.
  - Additional "planning funds" (~$1.5M/yr) will be sought directly from NSF for the period FY17-FY20. Encouraging discussions with NSF ongoing.

U.S. Scope

- U.S. ATLAS has defined the scope of its potential contributions to the HL-LHC upgrades.
  - Driven by the interests and experience of the U.S. groups.
  - Discussion within collaboration and building of consensus was vital.
  - Active discussions with international ATLAS at all levels to ensure that U.S. planning is integrated at the overall collaboration level.
- **DOE Scope:**
  - Focuses on the production of the Barrel ITk (Pixel and Strip detector) and associated common support infrastructure; DAQ hardware focusing on data flow elements, and FE analog chip development for LAr.
  - Significant involvement of four national Labs: ANL, BNL, LBNL, SLAC and leveraged with University contributions.
- **NSF Scope:**
  - Development of the trigger and readout electronics for LAr, Tile, Muons in support of providing robust trigger strategies at high luminosities.
  - Significant involvement of NSF supported Universities.

Project Organization (L2)



*: A small fraction of the LAr deliverable falls under DOE scope

Basis Of Estimates (BoE)

❖ BoE’s have been prepared for each deliverable providing details about the scope and cost justification.

- Much of the M&S costs were estimated at the international ATLAS level.
  - That used initial vendor quotes, scaling from prototypes, or prior experience to estimate the costs.
- A list of sub-deliverables (items) and associated tasks were defined for each deliverable.
  - This allowed us to estimate the amount of Labor (FTE) needed for each task. Many of these estimates are based on prior experience (incl. Phase I upgrades), working with prototypes, or discussions with engineering experts.
  - Institutional Labor rates were used in determining the associated costs that includes the standard inflation for out-years.
  - Travel costs were also included.
- The L2 managers are prepared to discuss the details of these cost estimates at their respective breakout sessions.

Risks

- A draft Risk Management Plan document has been prepared, based on Phase I. The intent is to provide a structured and integrated process for managing project risks in three categories: cost, schedule and scope/technical performance.
- In addition, we have prepared two preliminary Risk Registries:
  - Deliverable Risk Registry and a Global Risk Registry
- Deliverable Risk Registry: (Principal risks)
  - For each deliverable, we have identified the primary Cost, Schedule and Technical Risks associated with it. We have set a flag "Low", "Moderate", "High" to describe the severity of the risk.
- Global Risk Registry:
  - In addition to deliverable risks, we have identified initial general risks with an associated severity, that may have an impact on multiple deliverables.
- While we have identified these risks, their quantitative assessment and translating that into a contingency will be done as the project advances.

Contingency Estimates

- A top-down contingency has been set for each L2 following the guidelines that have been adopted from Phase I project.

6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	6.10
Pixel	Strip	Glb. Mech	LAr	Tile	Muon	Trigger	DAQ	Common	Prj. Mgmt
45%	**45%**	**45%**	**35%**	**35%**	**35%**	**50%**	**50%**	**25%**	**20%**

  - LAr, Tile & Muon readout Electronics: Adapted from earlier designs. Good confidence in effort based on experience from original construction/Phase I.
  - ITk: Ongoing R&D effort with designs not fully converged. And labor estimated from previous similar experience and work on prototypes.
  - Trigger/DAQ: Final architecture not yet in place with tasks not fully defined, however experience from previous effort.
  - Common and Project: High confidence in estimated effort.
  - In addition, a preliminary global contingency of 5% has been included to cover identified global risks based on Phase I experience.
  - The total budget contingency for the project is 43%
  - We are also developing a scope contingency as part of the risk mitigation strategy in conjunction with the budget contingency.

DOE Cost Summary

U.S. ATLAS HL-LHC Upgrade Project DOE Cost Summary (AYk$)											
WBS	Description	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	Total
6.1	Silicon Pixels	-	2,400	5,056	8,610	6,654	4,105	1,213	297	-	28,336
6.2	Strips Tracker	1,000	6,443	10,720	8,980	5,197	5,031	567	-	-	37,938
6.3	Global Mechanics	-	707	884	2,069	1,744	752	311	205	-	6,672
6.4	LAr	-	868	1,034	1,152	980	1,004	500	514	-	6,053
6.5	Tile	-	-	-	-	-	-	-	-	-	-
6.6	Muon	-	-	-	-	-	-	-	-	-	-
6.7	Data Handling/DAQ	-	46	867	1,581	1,791	2,044	2,481	-	-	8,811
6.8	Trigger	-	-	-	-	-	-	-	-	-	-
6.9	Common	-	-	-	2,352	-	-	-	-	-	2,352
6.10	PM	250	1,363	2,080	2,081	2,133	2,112	2,168	2,005	574	14,766
	Subtotal	1,250	11,828	20,642	26,826	18,500	15,049	7,240	3,021	574	104,929
	Contingency	-	2,172	8,709	11,427	7,783	6,246	2,790	807	115	40,048
	Global Contingency	-	-	1,032	1,341	925	752	362	151	459	5,023
	DOE Project Total	1,250	14,000	30,383	39,595	27,208	22,047	10,392	3,979	1,147	150,000
ref line	DOE Project guidance	1,250	14,000	31,500	42,300	26,100	20,100	10,000	4,750	-	150,000
									overall contingency		43%

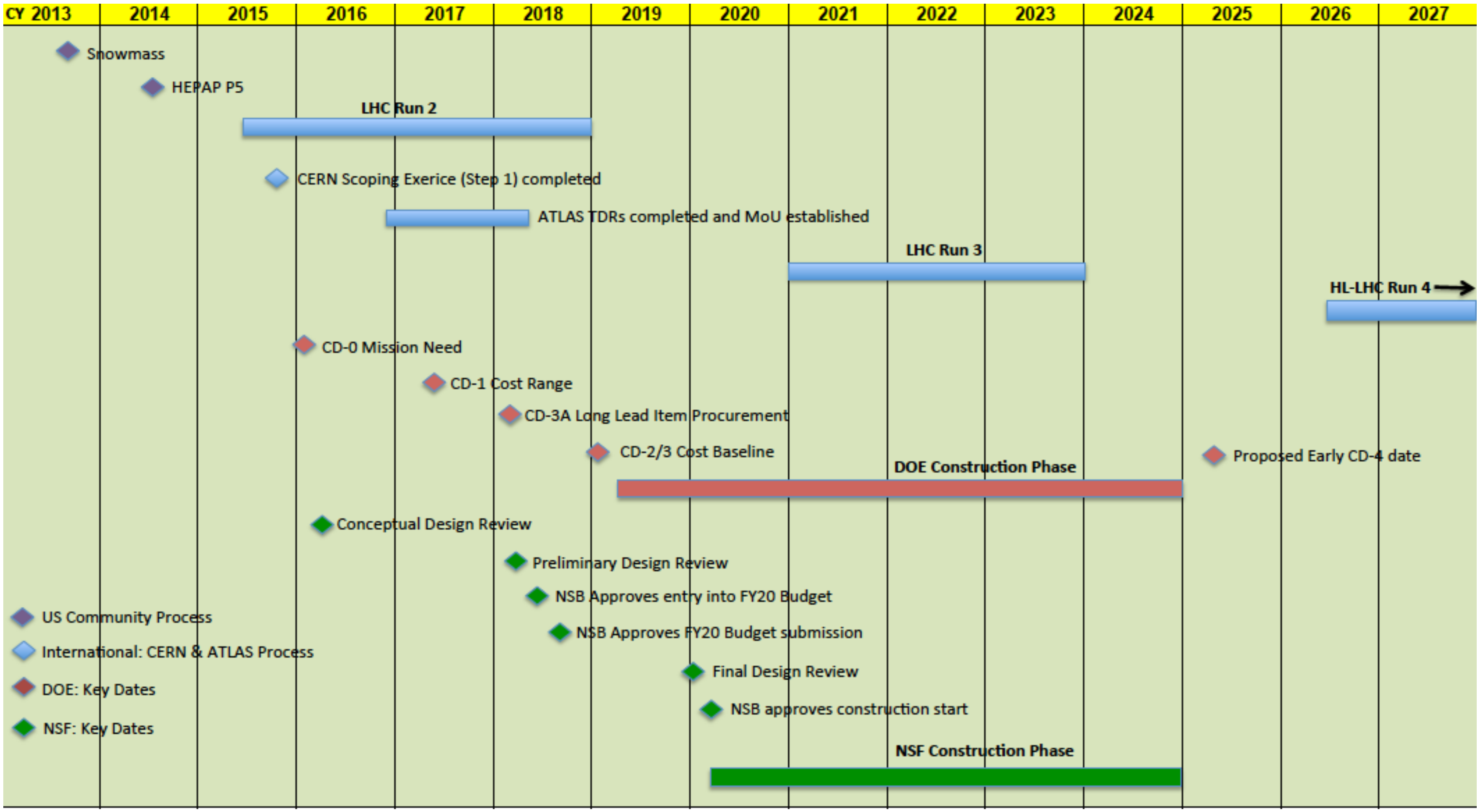
Details in the breakout sessions

NSF Cost Summary

U.S. ATLAS HL-LHC Upgrade Project NSF Cost Summary (AYk$)								
WBS	**Description**	**FY20**	**FY21**	**FY22**	**FY23**	**FY24**	**FY25**	**Total**
6.1	Silicon Pixels	-	-	-	-	-	-	-
6.2	Strips Tracker	-	-	-	-	-	-	-
6.3	Global Mechanics	-	-	-	-	-	-	-
6.4	LAr	3,371	4,624	4,581	3,805	2,686	-	19,067
6.5	Tile	1,085	1,708	708	209	33	-	3,743
6.6	Muon	1,291	3,868	2,869	2,659	277	-	10,964
6.7	Data Handling/DAQ	-	-	-	-	-	-	-
6.8	Trigger	1,029	1,943	2,215	6,980	343	-	12,510
6.9	Common	1,174	-	-	-	-	-	1,174
6.10	PM	858	930	957	984	1,012	342	5,083
	Subtotal	8,808	13,073	11,331	14,636	4,351	342	52,540
	Contingency	3,182	4,728	4,155	6,022	1,422	68	19,577
	Global Contingency	440	654	567	732	218	274	2,884
	NSF Total	**12,430**	**18,454**	**16,052**	**21,390**	**5,991**	**684**	**75,000**
						overall contingency		**43%**

Details in the breakout sessions

Key DOE/NSF dates



Addressing the Charge

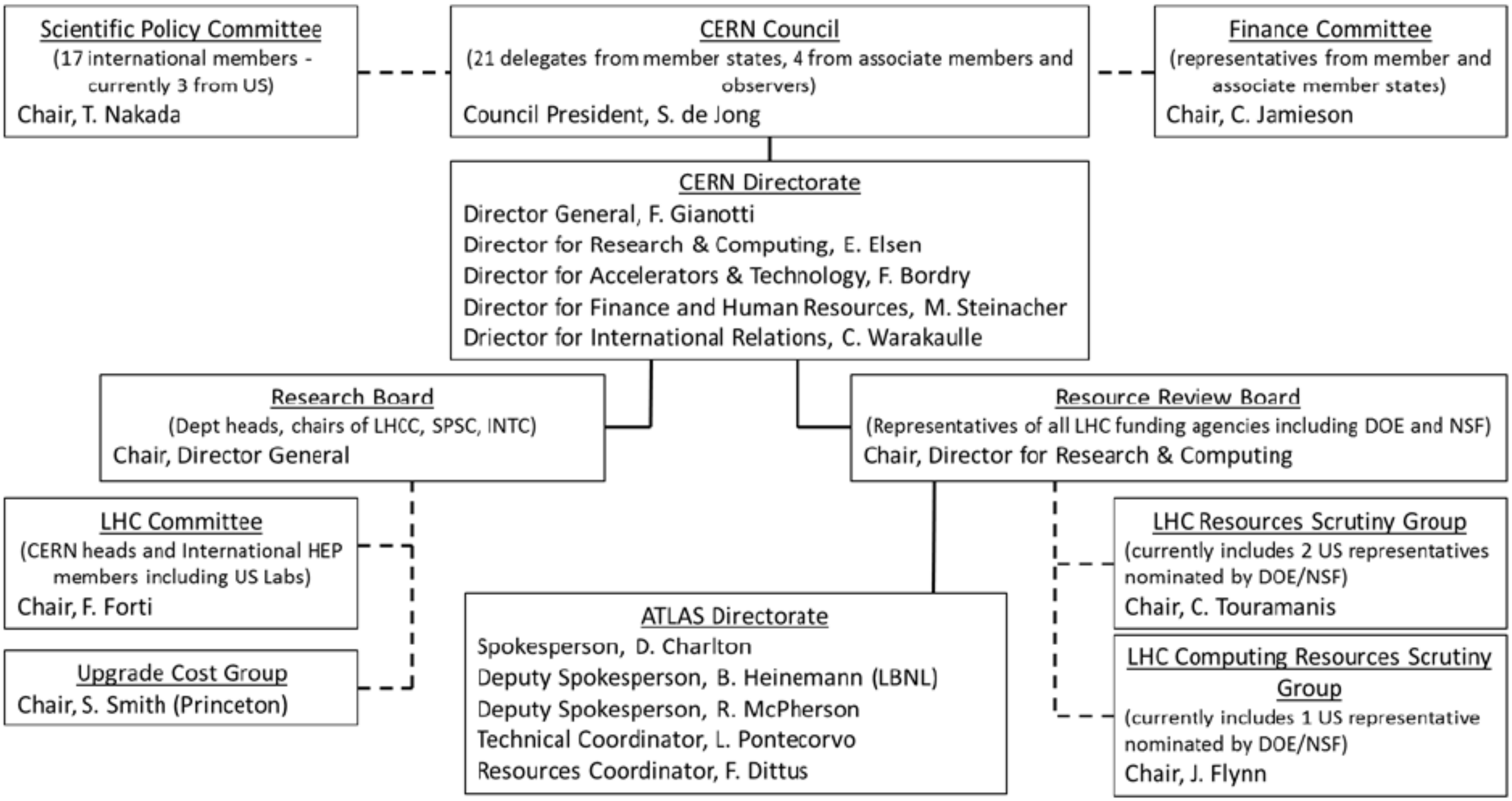
1. Design: Summarized in Hal's talk, details in L2 managers talks.
2. R&D: A summary in L2 manager's talk, and a dedicated talk during breakout session
3. Scope: Covered in Hal's talk and detailed in L2 talks.
4. Cost & Schedule: Summary in this talk + mgmt breakout, L2's will provide details of their respective systems + BoEs.
5. Risks: Summary in this talk + mgmt breakout, Deliverable risk will be described by respective L2 managers.
6. Management & ES&H: This talk + mgmt breakout.
7. Documentation: NSF CDR and PEP described in Mike's talk.

❖ Documentation for all of the above can be found at:

http://www.usatlas.bnl.gov/HL-LHC/reviews/Director's_Review_Jan_2016/

Backup

CERN Organization



ATLAS Organization

ATLAS Collaboration Board
Chair, K. Tokushuku
Deputy, H. Gordon (BNL)

ATLAS Collaboration
Board Advisory Group

ATLAS Spokespeople
Spokesperson, D. Charlton
Deputy Spokesperson, B. Heinemann (LBNL)
Deputy Spokesperson, R. McPherson

Technical Coordinator
L. Pontecorvo

Resource Coordinator
F. Dittus

National Contact Physicists
Resource Coordinator (Chair)
Includes US ATLAS OPM, DOPM

Institute Boards
Each detector subsystem (ID, Lar, TileCal, Muon, Forward, Trigger/DAQ) has an Institute Board with representatives from each collaborating institute involved in that subsystem

Executive Board
Spokesperson, D. Charlton (chair)
Deputy Spokesperson, B. Heinemann (LBNL)
Deputy Spokesperson, R. McPherson
Resource Coordinator, F. Dittus
Technical Coordinator, L. Pontecorvo
Collaboration Board Chair, K.Tokushuku
Inner Detector Project Leader, D. Robinson
LAr Calorimeter Project Leader, M. Aleksa
Tile Calorimeter Project Leader, I. Vichou (UIUC)
Muon Project Leadser, C Amelung (Brandeis)
Forward Detectors Project Leader, M. Bruschi
Trigger/DAQ PL, D. Strom (Oregon)
Detector Operations & Run Coordination, A. Polini
Trigger Coordination, A. Sfyrla
Computing Coordination, E. Lancon
Data Prep Coordination, P. Laycock
Physics Coordination, M. Kado
PubComm Chair, P. de Jong
Upgrade Steering Group Coordinator, K. Einsweiler (LBNL)
Additional Members, K. Jacobs, S. Jin, O. Solovyanov

DOE (Latest Guidance)

	DOE: HL-LHC ATLAS Detector Upgrade Project (AY$ Millions)									
Fiscal Year	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
Other Project Costs	1.5	5.0	14.0							**20.5**
Total Equipment Costs				31.5	42.3	26.1	20.1	10.0	4.5	**134.5**
Total Project Costs	**1.5**	**5.0**	**14.0**	**31.5**	**42.3**	**26.1**	**20.1**	**10.0**	**4.5**	**155.0**

[1] Funding for Other Project Costs (OPC) in FY 2016 will be redirected from the U.S. ATLAS Operations program. The FY 2017 budget request shows $1.25 million for HL-LHC ATLAS Upgrade OPC. It may be necessary to redirect additional funds from the U.S. ATLAS operations program to support the conceptual design.

All planning and presentations at this review are based on the original guidance.

R&D Budgets

	FY 16	FY 17	FY 18	FY 19	FY 20	Total (AYk$)
LAr	**547**	683	900	1050	300	2933
TileCal	**632**	513	312	659	335	1819
Muons	**191**	222	681	1297	506	2706
Trigger	**0**	220	390	366	461	1437
Total (NSF)	**1370**	**1638**	**2283**	**3372**	**1602**	**8895**
LAr	200	200				400
ITk	2912	1600				4512
Total (DOE)	**3112**	**1800**				**4912**

On DOE side: transition to OPC funds in FY17. [New] OPC guidance in FY17 set at $1.25M. Insufficient to sustain completion of the design work. Additional planned contribution from Operations Program is $1.8M for ITk and LAr, for a total available funds = $3.05M.

On the NSF side: $1M per year from FY17 – FY20 planned support from Operations Program, Additional $1.5M/year for 4 years from additional "Planning Funds".
Total available pre-MREFC funds = $10M.

Project Office (Project supported)

	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	Total	Description
DOE Project Supported Project Office Staff											
Project Manager	0	1	1	1	1	1	1	1	0.5	**7.5**	Oversight and Management of Project
Project Engineer	0	1	1	1	1	1	1	1	0	**7**	Technical oversight
Finance/Scheduler 1	0	1	1	1	1	1	1	1	0.5	**7.5**	Project tracking and reports
Finance/Scheduler 2	0	0	1	1	1	1	1	1	0	**6**	Project tracking and reports
P6 contractor	1	1	1	0.75	0.75	0.375	0.375	0.25	0	**5.5**	Development and management of P6 tools
Adminstrator	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**4**	General administration
Sub-System Integrator	0	0.44	1.2	1.2	1.2	1.2	1.2	0.6	0	**7.04**	Develop and verify interface compliance
NSF Project Supported Project Office Staff											
Deputy Project Manager				0.375	0.75	0.75	0.75	0.75	0.375	**3.75**	Oversight and Management of Project
System Integration				0.5	1	1	1	1	0	**4.5**	Develop and verify interface compliance
Financial Analyst				0.25	0.5	0.5	0.5	0.5	0	**2.25**	Project tracking and reports
Administrator				0.25	0.5	0.5	0.5	0.5	0.5	**2.75**	General Administration
Project Controls				0.5	1	1	1	1	0.25	**4.75**	Budget administrator

Additional off-project support for FY16 – FY17 (for DOE) and FY16 – FY20 (for NSF), next slide

Project Office (Off-Project)

	FY16	FY17	FY18	FY19	FY20	Total	Funding Source
DOE Off-Project Supported Project Office Staff							
Project Manager	0.5	0.5	0	0	0	1	Research Program
Project Engineer	0	0	0	0	0	0	
Finance/Scheduler 1	0.5	0.5	0	0	0	1	Operations Program
Finance/Scheduler 2	0	0	0	0	0	0	
P6 contractor	0.25	0	0	0	0	0.25	Operations Program
Adminstrator	0.25	0.25	0	0	0	0.5	Operations Program
Sub-System Integration	0	0	0	0	0	0	
NSF Off-Project Supported Project Office Staff							
Deputy Project Manager*	0.17	0.17	0.17	0.17	0.375	1.055	Ops/Planning Funds
System Integration	0	1	1	1	0.5	3.5	Planning Funds
Financial Analyst	0	0	0	0	0.25	0.25	Planning Funds
Administrator	0.25	0.5	0.5	0.5	0.25	2	Ops/Planning funds
Project Controls	0.5	1	1	1	0.5	4	Ops/Planning funds

* : Additionally supported by Research Program to ensure a total of 0.5 FTE level effort

Off-Project funds also support members of Management Team,ES&H & QA/QC Liaison

PO: FY16-FY17 effort description

- First sub-system to be supported using Project Funds is the ITk Strip Detector:
  - Setting up accounts for Strips (supported by project beginning FY17): 6 institutions and 11 accounts
  - Setup MOU & contracts with these institutions
  - Setup status reporting (technical & financial) and tracking status
  - Invoice approvals
- Updating cost estimates and BoEs for all sub-systems
- Setting up P6 infrastructure
  - uploading data
  - validation and consistency checks
- Preparation for CD-1 review
- Preparing for FY18 and projectizing all sub-systems
- Incorporating recommendations of various reviews
  - Revising P6 with detailed schedules and milestones

ATLAS Upgrade Approval Process

- Within each subsystem there are discussions and reviews of components
- Once R&D is sufficiently mature, the subsystem leaders schedule an Initial Design Review (IDR) based on a comprehensive design document
  - Overall performance, technical requirements, initial cost estimate, preliminary schedule and milestones
- The sub-system project is formalized and launched after the IDR is completed. Initial institutional interests to the upgrades are collected.
- The project moves to the TDR stage. Final commitments are made following the completion of the TDR. These MoUs specify the formal engagements with each country.

Table 26. IDR and TDR schedule of the ATLAS Phase-II UPRs

Upgrade PRoject (UPR)	IDR	TDR
ITk-Strip ITk-Pixel	Q4 2014	Q4 2016 Q4 2017
LAr	Q3 2016	Q3 2017
TileCal	Q3 2016	Q3 2017
Muon	Q2 2016	Q2 2017
TDAQ	Q1-2016	Q4 2017

Core Cost Estimate

Core Cost : closest equivalent is the M&S without prototypes or contingencies added

WBS	Description	US CORE Cost (k$) FY18	FY19	FY20	FY21	FY22	FY23	FY24	Total	US Total kCHF	ATLAS Total kCHF	US Fraction
6.1	Pixels	-	400	4,723	3,533	419	589	567	10,231	9,719	43,750	22%
6.2	Strips	427	5,041	3,771	1,036	646	-	-	10,921	10,375	60,530	17%
6.3	ITK Common	-	-	1,450	1,105	125	-	-	2,680	2,546	16,080	16%
6.4	Liquid Argon	-	-	-	1,777	2,025	1,888	1,050	6,740	6,403	45,980	14%
6.5	TileCal	-	-	708	1,003	149	26	-	1,886	1,792	8,580	21%
6.6	Muon	-	-	236	1,719	1,004	1,831	-	4,790	4,551	34,080	13%
6.7	DAQ/Data	-	-	-	-	703	1,393	-	2,095	1,990	43,310	18%
6.8	Trigger	-	-	-	-	649	5,507	-	6,156	5,848		
	Forward										1,300	
6.9	Common	-	-	3,526	-	-	-	-	3,526	3,350	17,420	19%
	TOTAL	**427**	**5,441**	**14,414**	**10,174**	**5,719**	**11,233**	**1,617**	**49,025**	**46,574**	**271,030**	**17%**

Cost Books

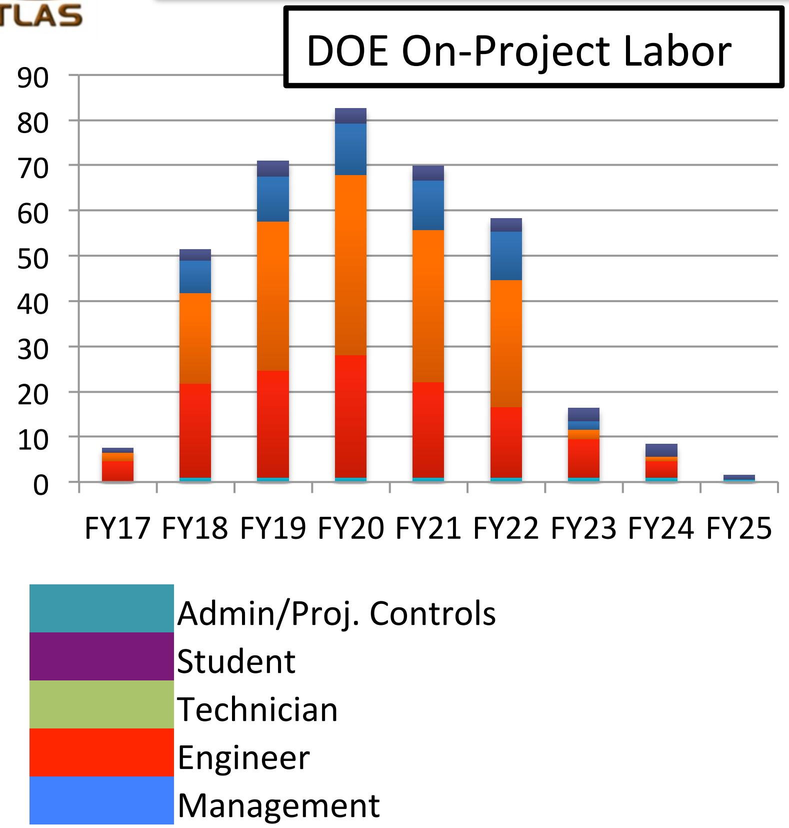
U.S. ATLAS HL-LHC Upgrade Project Level 1 DOE Total Costs (AYk$)										
	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	Total
DOE										
Labor	1,200	9,392	13,530	15,966	13,524	11,281	4,292	2,485	519	72,190
M&S	50	2,184	6,657	10,342	4,488	3,353	2,643	381	25	30,122
Travel	-	251	455	518	488	416	305	155	30	2,617
Subtotal	1,250	11,828	20,642	26,826	18,500	15,049	7,240	3,021	574	104,929
Contingency	-	2,172	9,741	12,769	8,708	6,998	3,152	958	574	45,071
DOE Total	**1,250**	**14,000**	**30,383**	**39,595**	**27,208**	**22,047**	**10,392**	**3,979**	**1,147**	**150,000**

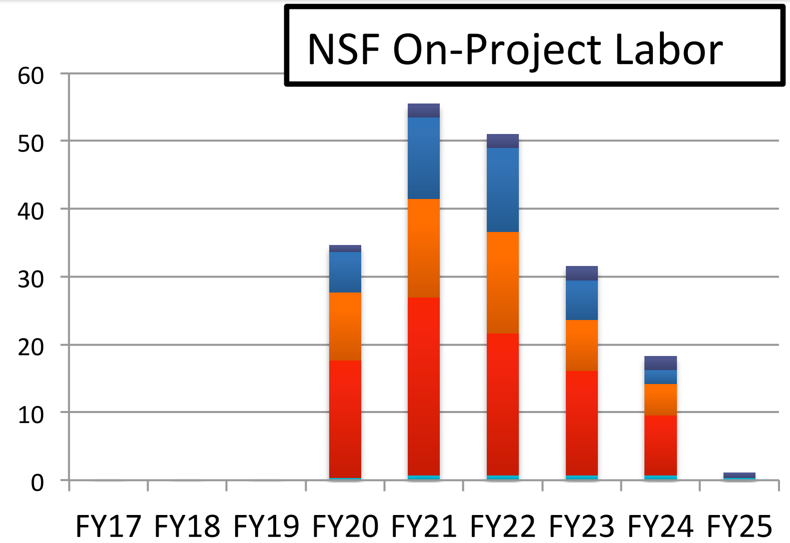
U.S. ATLAS HL-LHC Upgrade Project Level 1 NSF Total Costs (AYk$)							
	FY20	FY21	FY22	FY23	FY24	FY25	Total
NSF							
Labor	5,020	7,784	6,985	5,007	3,156	317	28,270
M&S	3,618	5,073	4,085	9,418	1,090	-	23,284
Travel	170	216	261	211	104	25	986
Subtotal	8,808	13,073	11,330	14,636	4,351	342	52,540
Contingency	3,622	5,381	4,721	6,754	1,640	342	22,460
NSF Total	12,430	18,454	16,052	21,390	5,991	684	75,000

Labor

DOE On-Project Labor Effort										
	FY17	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**	**FY24**	**FY25**	**Total**
Management	0	1	1	1	1	1	1	1	0.5	**7.5**
Engineer	4.67	20.74	23.61	27.05	21.13	15.55	8.48	3.6	0	**124.83**
Technician	1.8	20.01	33	39.85	33.58	28.1	2.08	1	0	**159.42**
Student	0.04	7.19	9.9	11.4	10.91	10.71	1.9	0	0	**52.05**
Admin/Proj. Controls	1	2.5	3.5	3.25	3.25	2.88	2.88	2.75	1	**23.01**
Total	**7.51**	**51.44**	**71.01**	**82.55**	**69.87**	**58.24**	**16.34**	**8.35**	**1.5**	**366.81**
NSF On-Project Labor Effort										
	FY17	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**FY23**	**FY24**	**FY25**	**Total**
Management	0	0	0	0.38	0.75	0.75	0.75	0.75	0.38	**3.76**
Engineer	0	0	0	17.28	26.19	20.9	15.37	8.83	0	**88.57**
Technician	0	0	0	10.02	14.57	14.95	7.57	4.65	0	**51.76**
Student	0	0	0	5.99	11.97	12.38	5.82	2.04	0	**38.2**
Admin/Proj. Controls	0	0	0	1	2	2	2	2	0.75	**9.75**
Total	**0**	**0**	**0**	**34.67**	**55.48**	**50.98**	**31.51**	**18.27**	**1.13**	**192.04**

Labor


DOE On-Project Labor
90
80
70
60
50
40
30
20
10
0
FY17 FY18 FY19 FY20 FY21 FY22 FY23 FY24 FY25
Admin/Proj. Controls
Student
Technician
Engineer
Management


NSF On-Project Labor
60
50
40
30
20
10
0
FY17 FY18 FY19 FY20 FY21 FY22 FY23 FY24 FY25

Global Risk Registry (partial)

Global Risk Registry: HL-LHC Upgrade			Risk Evaluation				Residual Cost and Schedule Impacts						
ID	Title	Risk Owner	Cost	Schedule	Scope	Overall Risk Score	Cost (AYk$)	Schedule (months)	Probability	Cost X Probability (AYk$)	Cost: 90% CL Limit (AYk$)*	Schedule Impact X Probability (months)	Notes
PM-001	Delays in LHC schedule leading to delays in international approval stages (TDR, PRR, etc.)	Rajagopalan, Tuts	M	H	N	M							Delays in international approval can consequently delay the start and completion of the production phase resulting in the need to retain personnel for longer duration. It could also potentially lead to additional design iterations leading to further risks and delays.
PM-002	Delay in receiving future critical decisions (CD-2/3a/3)	Rajagopalan	H	M	L	M							Delays to start of production could imply increased cost to account for a shorter production phase, increase risk to completion and maintaining scope and schedule.
PM-003	Delay in NSF PDR/FDR	Tuts	H	M	M	M							Delays in the availability of NSFproject funds increases schedule risks and consequently increasing costs to account for shorter production time and risks the ability to meet the commitments to U.S. scope.
PM-004	Uncertainty in Operations Program Funding from DOE	Rajagopalan	L	M	L	M							Insufficient funds to complete R&D increases risk to begin production in a timely manner.
PM-005	Uncertainty in NSF planning funds.	Tuts	L	M	L	M							NSF planning funds between CDR and FDR are critical for completion of the R&D and ensuring project readiness for the construction phase.
PM-006	Dependencies on International Partners	Rajagopalan	L	M	L	L							Failure to maintain schedule in design and development can cause delayed start of production. Failure for international partners to deliver on their commitments can have an impact on the U.S.

DocDb 91: Linked from http://www.usatlas.bnl.gov/HL-LHC/reviews/Director's_Review_Jan_2016/

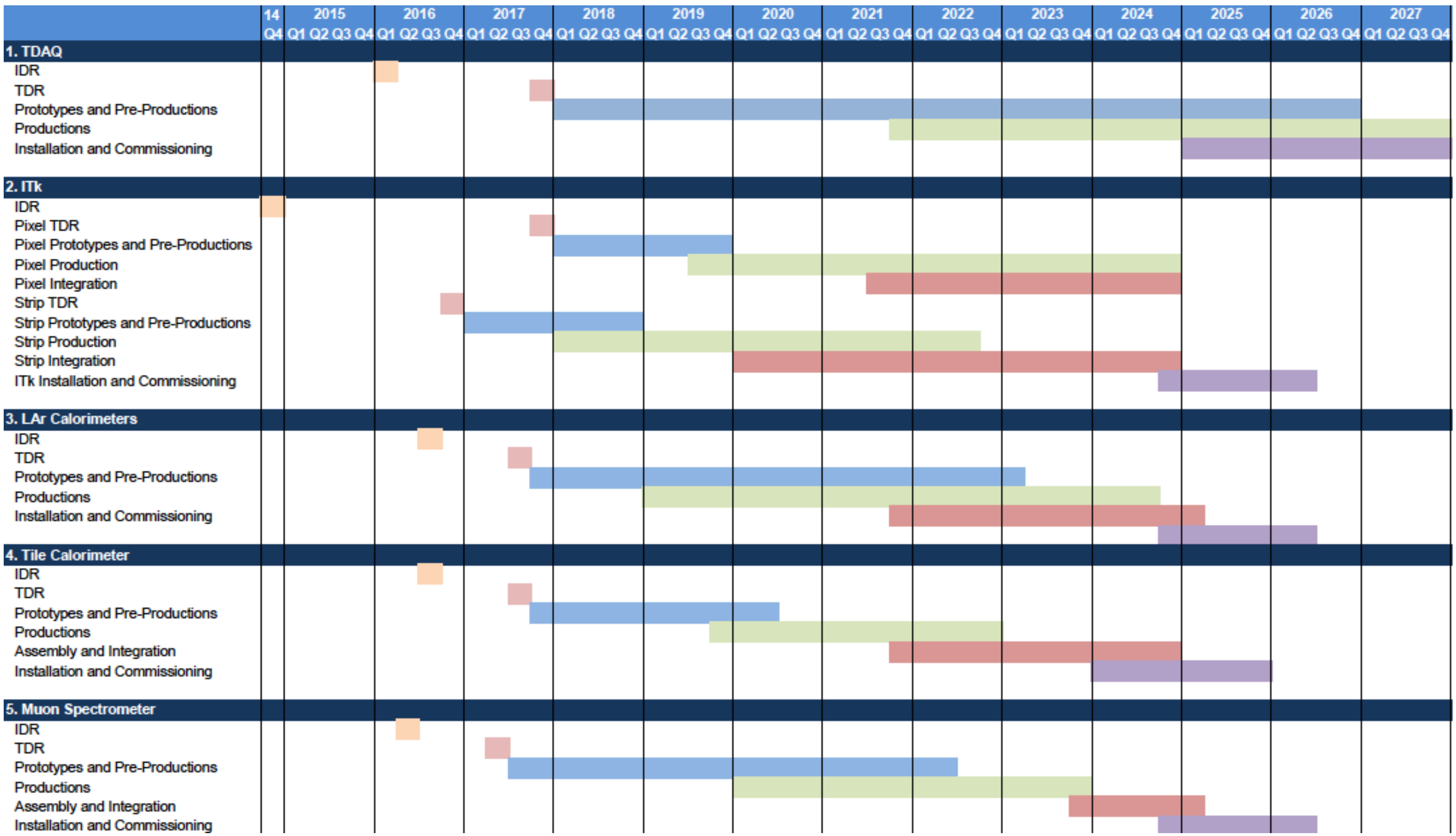
Deliverable Risk Registry (partial)

HL-LHC Upgrade Project Risk Registry for L2 Systems
January 4, 2016

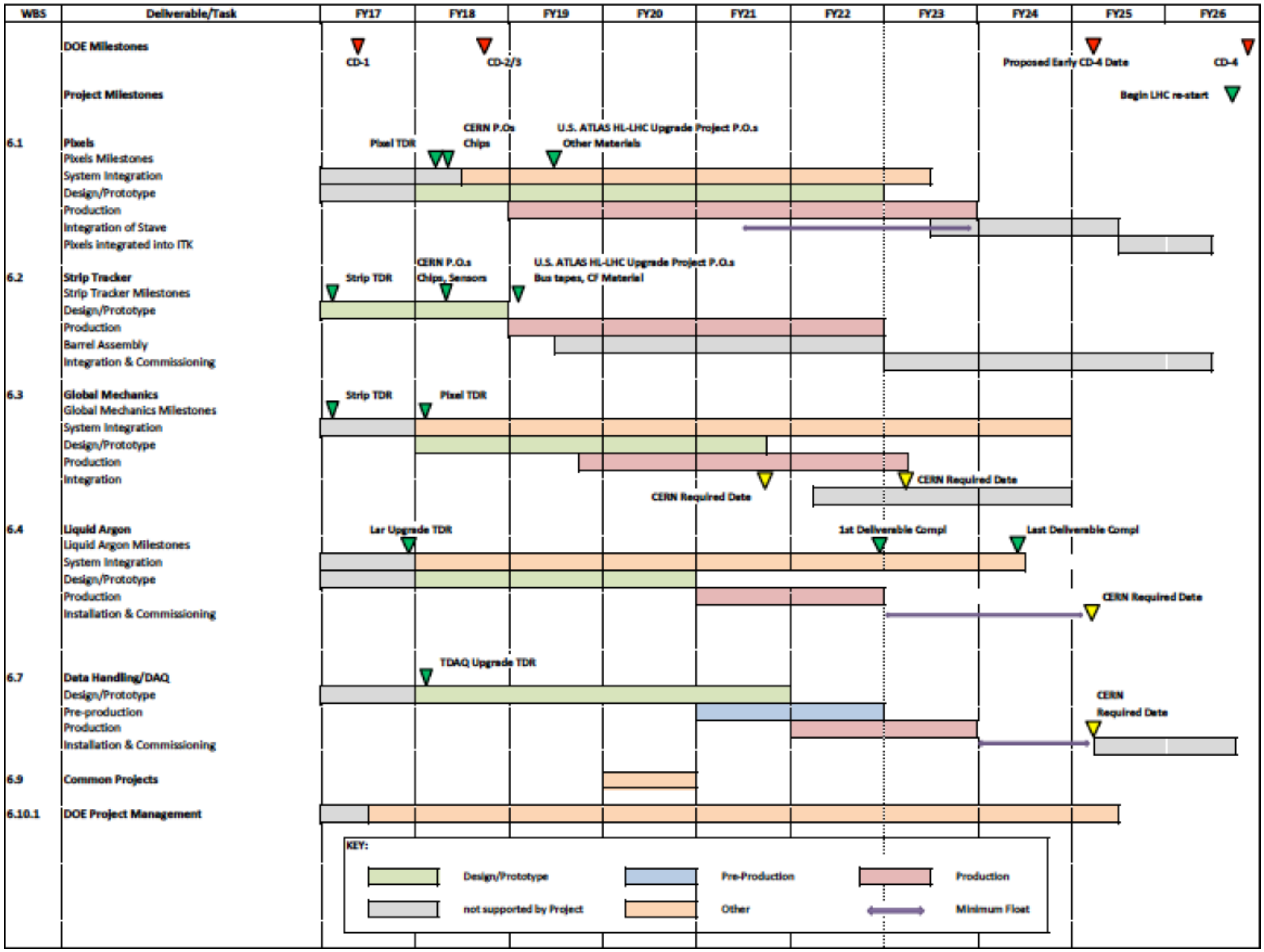
WBS	Title	Risk Owner	Risk Evaluation (L/M/H) Cost	Schedule	Scope	Contingency %	Contingency AY$	Average Risk Score	Identified Risks (See BoEs)
6.1	Pixels	Grenier, Philippe				45%	12,751	4.0	
6.1.x.1	Pixels Integration	Grenier, Philippe	L	L	L	45%	212	1.0	n/a
6.1.x.2	Pixels Mechanics	Grenier, Philippe	L	L	L	45%	575	2.0	*Technical diffculties require additional design and/or additional prototyping cycle. *Uncertainty in number of prototypes needed and complexity.
6.1.x.3	Pixels Services	Grenier, Philippe	L	L	L	45%	1,962	2.0	* The two prototypes cycles budgeted for the receiver array ASIC may not be sufficient. *The number of optical links is still unknown
6.1.x.4	Pixels Local Supports	Grenier, Philippe	M	L	M	45%	4,737	4.5	* Late delivery of parts introduces delay. *Design effort could be required to modify system to reflect issue identified during prototyping and/or production. *Scope exceeds available funds. *Specifications are delayed
6.1.x.5	Pixels Modules	Grenier, Philippe	M	M	M	45%	3,938	5.5	*Technical diffculties require additional design and/or additional prototyping cycle. *Re-design needed as a result of production problem. *Late change of specifications trigger re-design work. *Wire-bonder breakdown.*Late delivery of parts impacts schedule
6.1.x.6	Off-Detector Electronics	Grenier, Philippe	M	M	M	45%	616	5.0	*Specifications are delayed. *Number of power supplies are not known
6.1.x.7	Supports	Grenier, Philippe	L	M	L	45%	711	3.0	*Design effort could be required to modify system to reflect issue identified during production. *Catastrophic failure of test hardware. *Delayed specifications of the pixel readout chip. *Delayed availability of parts. *Significantly different pieces of firmware may be required.

DocDb 77: Linked from http://www.usatlas.bnl.gov/HL-LHC/reviews/Director's_Review_Jan_2016/

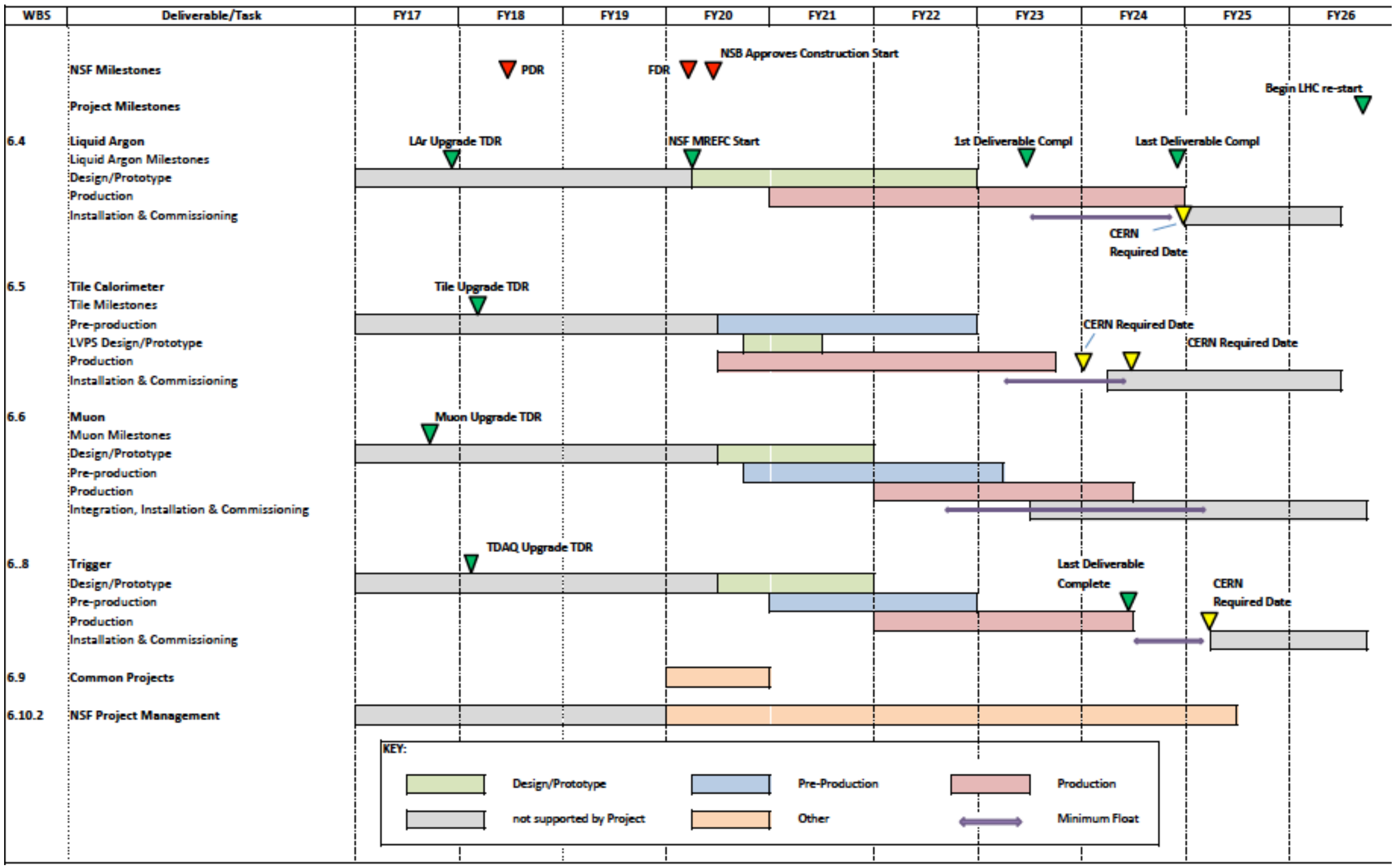
Current ATLAS Schedule



Schedule (DOE)



Schedule (NSF)



Schedule Float (DOE)

6.a.x.b: a = sub-system, x = institute, b = deliverable

DOE Deliverables Schedule Float to Installation

	WBS	Title	Acceptance Test Complete (Mo/Yr)	CERN Required Date (Mo/Yr)	Minimum Float to CERN required date (months)
	6.1.x.1	System Integration	Mar-23	Dec-23	8
	6.1.x.2	Pixel Mechanics	Mar-21	Apr-22	12
	6.1.x.3	Services	Sep-22	Jul-23	9
Pixels	6.1.x.4	Local Supports	Mar-23	Oct-23	6
	6.1.x.5	Modules	Jun-22	Jan-23	6
	6.1.x.6	Off-Detector Electronics	Mar-23	Oct-23	6
	6.1.x.7	Support	Sep-23	Dec-23	2
	6.2.x.1	Stave Core	Sep-21	Sep-21	0
Strips	6.2.x.2	Readout/Control Chips	Sep-21	Sep-21	0
	6.2.x.3	Modules & Integration	Sep-22	Sep-22	0
	6.3.x.1	Integration System Test	Sep-24	N/A	-
Global Mechanics	6.3.x.2	Outer Cylinder & Bulkhead	Jun-21	Jul-21	0
	6.3.x.3	Thermal Barrier	Jun-21	Jul-21	0
	6.3.x.4	Pixel Support Tube	Dec-22	Apr-21	3
Liquid Argon	6.4.x.4	System Integration	Mar-24	Jan-25	10
	6.4.x.5	PA/Shaper	Sep-22	Jul-23	9
	6.7.x.1	L1 Global Aggregator	Sep-22	Dec-24	26
Data Handling/DAQ	6.7.x.2	L1 Track Input	Sep-23	Dec-24	14
	6.7.x.3	DAQ/FELIX	Sep-23	Dec-24	14
	6.7.x.4	RoI Distributor	Sep-23	Dec-24	14

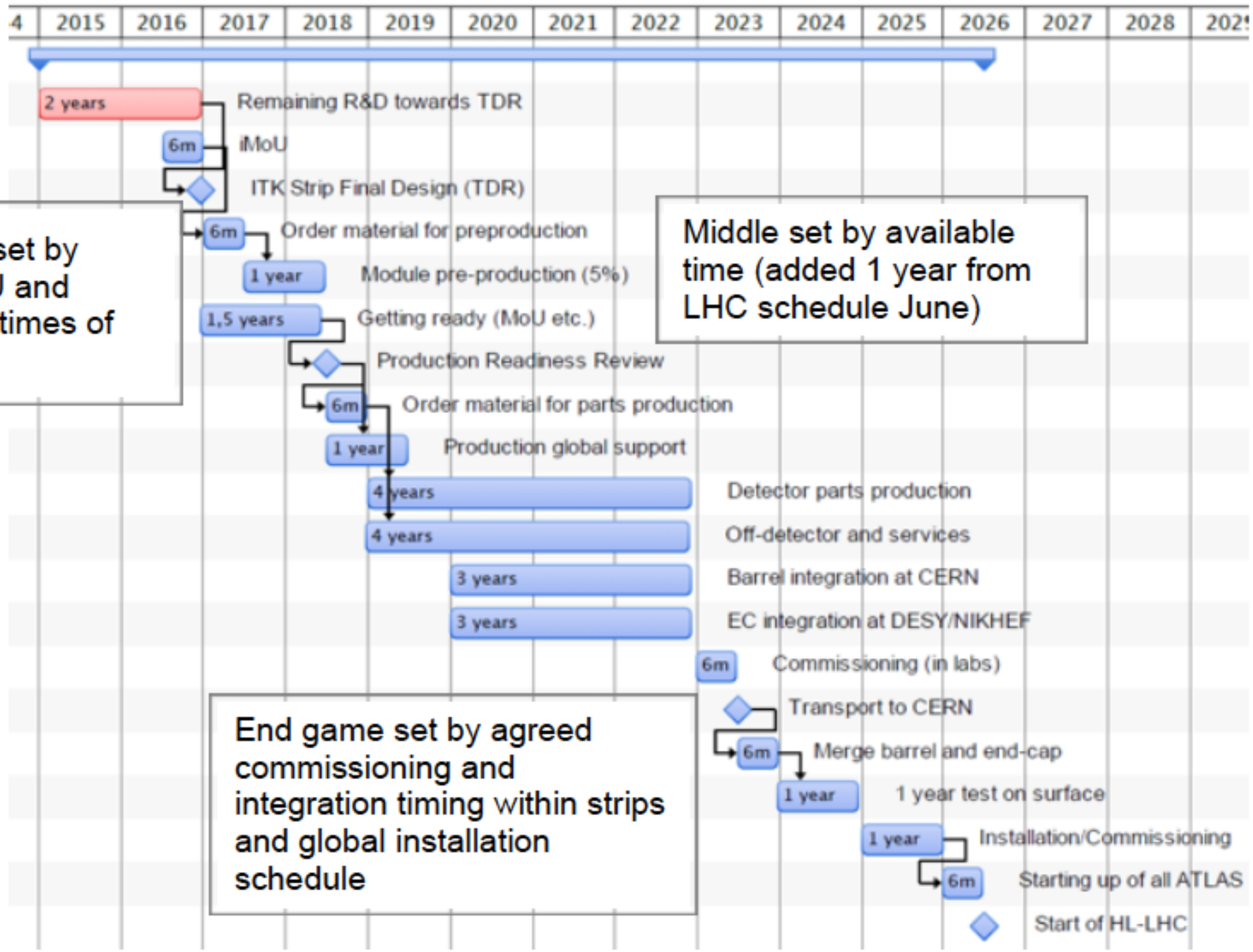
Schedule Float (NSF)

6.a.x.b: a = sub-system, x = institute, b = deliverable

NSF Deliverables Schedule Float to Installation

	WBS	Title	Acceptance Test Complete (Mo/Yr)	CERN Required Date (Mo/Yr)	Minimum Float to CERN required date (months)
	6.4.x.1	FE Electronics	Dec-23	Jan-25	12
Liquid Argon	6.4.x.2	Optics	Mar-23	Jul-23	3
	6.4.x.3	BE Electronics	Sep-24	Oct-24	0
	6.5.x.1	Main Board	Dec-22	Oct-23	9
Tile Calorimeter	6.5.x.2	Pre-Processor	Jun-23	Apr-24	9
	6.5.x.3	ELMB**Motherboards	Dec-22	Oct-23	9
	6.5.x.4	Low Voltage Power System	Dec-22	Oct-23	9
	6.6.x.1	Mezzanine	Jun-23	Apr-24	9
	6.6.x.2	TDC	Dec-22	Apr-24	15
Muon	6.6.x.3	CSM	Mar-23	Apr-24	12
	6.6.x.4	Hit Extraction Board	Mar-24	Jan-25	9
	6.6.x.5	sMDT Chambers	Jun-22	Apr-23	9
	6.8.x.1	L0Calo	Sep-23	Dec-24	14
Trigger	6.8.x.2	MDT Trigger	Mar-24	Dec-24	8
	6.8.x.3	L1 Global Processing	Sep-23	Dec-24	14
	6.8.x.4	L1 Track/FTK++ Processing	Mar-24	Dec-24	8

ATLAS Schedule for Strips



Beginning set by TDR, iMOU and production times of sensors

Middle set by available time (added 1 year from LHC schedule June)

End game set by agreed commissioning and integration timing within strips and global installation schedule

Scope (DOE)

WBS		Deliverable	Funding	Institutes	US Expertise
6.1	Pixels			Philippe Grenier (SLAC)	
	6.1.y.1	Pixels Integration	DOE	LBNL	Pixels in original detector & IBL
	6.1.y.2	Pixel Mechanics	DOE	LBNL, Washington	
	6.1.y.3	Pixels Services	DOE	OSU, SLAC	
	6.1.y.4	Local Supports	DOE	ANL, LBNL, SLAC, UCSC, UNM	
	6.1.y.5	Pixels Modules	DOE	ANL, LBNL, OKU, UCSC, UNM, Wash, Wisc	
	6.1.y.6	Off-Detector Electronics	DOE	OKS	
	6.1.y.7	Support	DOE	ANL, SB, SLAC, UNM, Washington	
6.2	Strips			Carl Haber (LBNL)	
	6.2.y.1	Stave Cores	DOE	BNL, IowaSt, LBNL, Yale	Strips in original detector
	6.2.y.2	Readout/Control Chips	DOE	BNL, LBNL, Penn, UCSC, Yale	
	6.2.y.3	Modules & Integration	DOE	BNL, Duke, LBNL, Penn, UCSC, TBD	
6.3	Global Mechanics			Eric Anderssen (LBNL)	
	6.3.y.1	Integration System Test	DOE	Indiana, LBNL, SLAC, UCSC	Mechanics in original detector
	6.3.y.2	Outer Cylinder & Bulkhead	DOE	LBNL	Low-mass support structures
	6.3.y.3	Thermal Barrier	DOE	SLAC	
	6.3.y.4	Pixel Support Tube	DOE	LBNL	
	6.3.y.5	DAQ Interface	DOE	SLAC, Washington	
6.4	Liquid Argon			John Parsons (Columbia)	
	6.4.y.4	System Integration	DOE	BNL	Similar syst. int. tests for original detector
	6.4.y.5	PA/Shaper	DOE	BNL, Penn	FE ASICs for original detector & Phase-I
	6.4.y.6	sFCAL	DOE	Arizona	FCAL in original detector
	6.4.y.7	HGTD	DOE	Iowa, Penn, SLAC, UCSC	Leverage ongoing US R&D
6.7	DAQ/Data Handling			Jinlong Zhang (ANL)	
	6.7.y.1	L1Global Aggregator	DOE	BNL	Phase-I gFEX
	6.7.y.2	L1Track/FTK++ Data	DOE	ANL, SLAC	Phase-0/1 FTK
	6.7.y.3	DAQ/FELIX	DOE	ANL, BNL	Phase-I FELIX
	6.7.y.4	RoID	DOE	ANL	Phase-I gFEX

Scope (NSF)

WBS		Deliverable	Funding	Institutes	US Expertise
6.4	**Liquid Argon**			**John Parsons (Columbia)**	
	6.4.y.1	Front End Electronics	NSF	Columbia, UTAustin	FE ASICs and FEB in orig detector & Phase-I
	6.4.y.2	Optics	NSF	SMU	Optics in original detector & Phase-I
	6.4.y.3	Back End Electronics	NSF	Arizona, SB	Phase-I LAr Digital Processing System
6.5	**Tile Calorimeter**			**Mark Oreglia (Chicago)**	
	6.5.y.1	Main Board	NSF	Chicago	MB in original detector
	6.5.y.2	Pre-Processor Interface	NSF	UTArlington	involvement in original sROD
	6.5.y.3	ELMB++ Motherboard	NSF	MSU	Tile DCS in original detector
	6.5.y.4	Low Voltage Power Supply	NSF	NIU, UTArlingron	Tile LVPS in Phase-0
6.6	**Muon**			**Tom Schwarz (Michigan)**	
	6.6.y.1	PCB for Mezzanine	NSF	Arizona	similar projects in original detector
	6.6.y.2	TDC	NSF	Michigan	extensive ASIC design experience
	6.6.y.3	CSM	NSF	Michigan	original detector
	6.6.y.4	Hit Extraction Board	NSF	Illinois	board design experience on CDF
	6.6.y.5	sMDT Chambers	NSF	Michigan, MSU	MDT production in original detector
6.8	**Trigger**			**Elliot Lipeles (Penn)**	
	6.8.y.1	L0Calo	NSF	MSU	built Phase-I system
	6.8.y.2	L0Muon	NSF	Irvine	extensive design experience at Irvine
	6.8.y.3	L1Global	NSF	Chicago, Indiana, LSU, MSU, Oregon, Pitt	Phase-I gFEX
	6.8.y.4	L1Track/FTK++ Processing	NSF	Indiana, Penn, Chicago, Illinois, NIU, Stanford	Phase-0/I FTK

ATLAS Major Scoping Decisions

System	TDR	Technical Decision (Date)
Pixels	Q4 2017	η coverage: 4.0 vs 3.2 (Sep. 2016) layout/mechanics: flat vs inclined modules (Sep. 2016)
Strips	Q4 2016	layout: move to 4-strip/5-pixel layers (Summer 2015)
Global Mech		Thermal shield: integrated with Outer Cylinder or not (strip TDR)
Liquid Argon	Q3 2017	PA/Shaper technology: BNL vs French (TDR) sFCAL yes or no (Jun. 2016) HGTD yes or no (May 2017)
TileCal	Q4 2017	FE chip: 3-in-1, QIE, FATALIC (Sep. 2017)
Muon	Q2 2017	replace BI chambers with sMDT/RPC (spring 2016) TDC technology: ASIC, FPGA, VMM-like (TDR) accessibility of inner chambers (TDR)
Trigger & DAQ	Q4 2017	architecture: L0/L1 vs L1-only (Summer 2016)

Technical Design Review for all sub-systems scheduled before end of CY 2017.

Scope Contingency

System	Scope Contingency	Savings	Impact/Assumption
6.1 Pixels	reduce: LV power, supports, stave flex, bump bonding, modules	$3.2M	materials picked up by others
6.2 Strips	deliver less cores/modules/staves	var	UK can do more
6.3 Global Mech	thermal barrier	$0.3M	may not be required
6.4 Liquid Argon	less firmware for BE produce less FEB2/ Otx/BE Mbs drop PA/shaper	$1M $1M $1M	find other groups may lose leadership may ==> non-opt readout
6.5 TileCal	drop LV box assembly	$0.4M	find other group
6.6 Muon	drop production of TDC (design only)	$1.2M	find other partners
6.7 DAQ/Data	produce less L1Track/FTK++ RTMs	$0.7M	find other partners
6.8 Trigger	drop 1 L1Global Algorithm produce less L1Track/FTK++ MBs	$0.4M $1.1M	find other group find others or reduced eff.

Scope Opportunity

System	Scope Opportunity	Cost	Benefit/Motivation
6.1 Pixels	buy 20% of sensors (cf 0%)	$1.7M	modules use US sensors
6.2 Strips	none	---	main areas assigned
6.3 Global Mech	common electr. (DAQ)	$1.5M	US experience here
6.4 Liquid Argon	sFCAL HGTD	$5.4M $5.3M	US-led effort significant US leadership
6.5 TileCal	produce all LVPS (cf 50%)	$1.1M	reduce external dependency
6.6 Muon	contribute to power supplies	$2M	may be needed
6.7 DAQ/Data	prod all L1Global aggr's (cf 50%) 30% FELIX card prod (cf 15%)	$0.7M $0.5M	reduce external dependency all needed for ITK integration
6.8 Trigger	add 1 L1Global Algo	$0.4M	US expertise here

ES&H

- ES&H issues will be integrated into all phases of planning and implementation through the final design and production processes of the US ATLAS HL-LHC project through Integrated Safety Management (ISM)
- We have a <u>draft</u> ES&H document – see docDB #2
- The overall safety plan assumes:
  - The Safety Liaison resides at BNL (given the experience);
  - The safety of work at collaborating institutions is the responsibility of each institutions safety management and will be conducted according to their safety protocols;
  - The safety of work at CERN will follow the safety and oversight programs at CERN.
- The Safety Liaison responsibilities include
  - Establishing safety procedures and rules;
  - Interfacing with BNL safety organizations;
  - Interfacing with collaborating institutions safety managements;
  - Establishing training that is needed to supplement BNL training requirements;
  - Ensuring that all work is reviewed and approved before it starts;
  - Representing safety concerns at engineering and design reviews;
  - Conducting incident investigations and reporting findings to project management.